Portable Emission Measurement Strategy

U.S. EPA

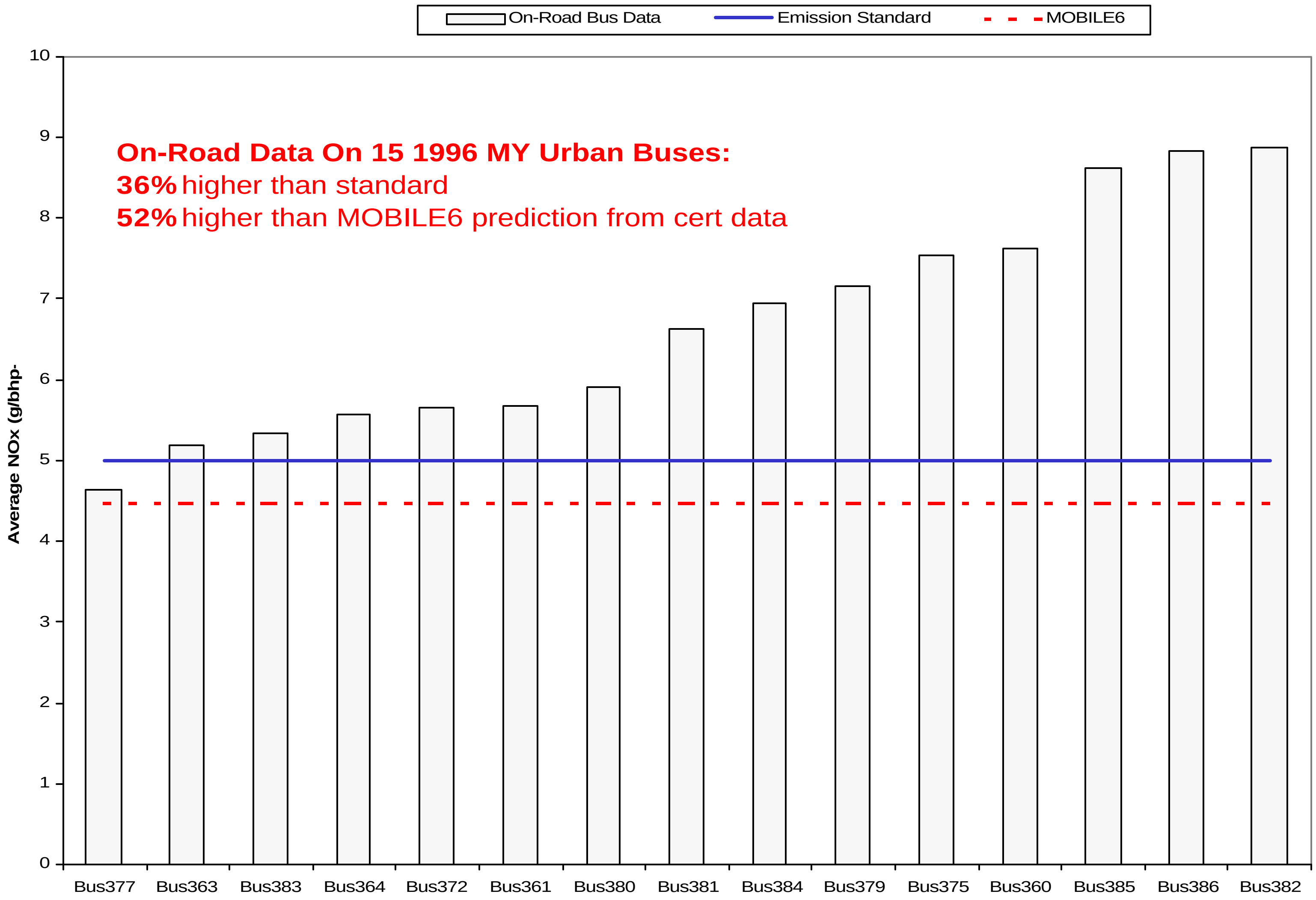
Office of Transportation and Air Quality

February 13, 2002

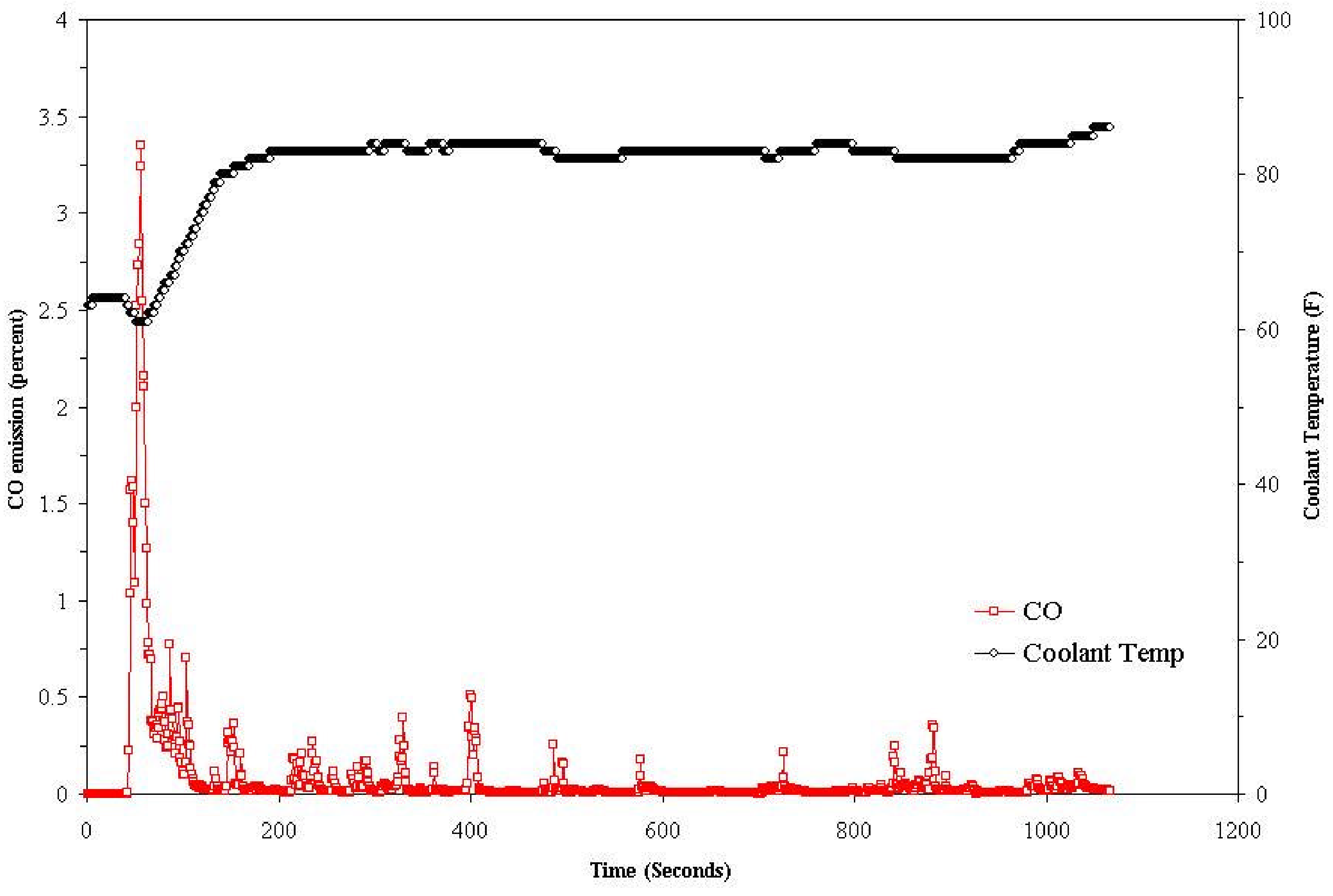
Why Not the Lab?

- Accuracy
- Cost
- Practicality
- Sample Bias and Recruitment
- New Technology is Available

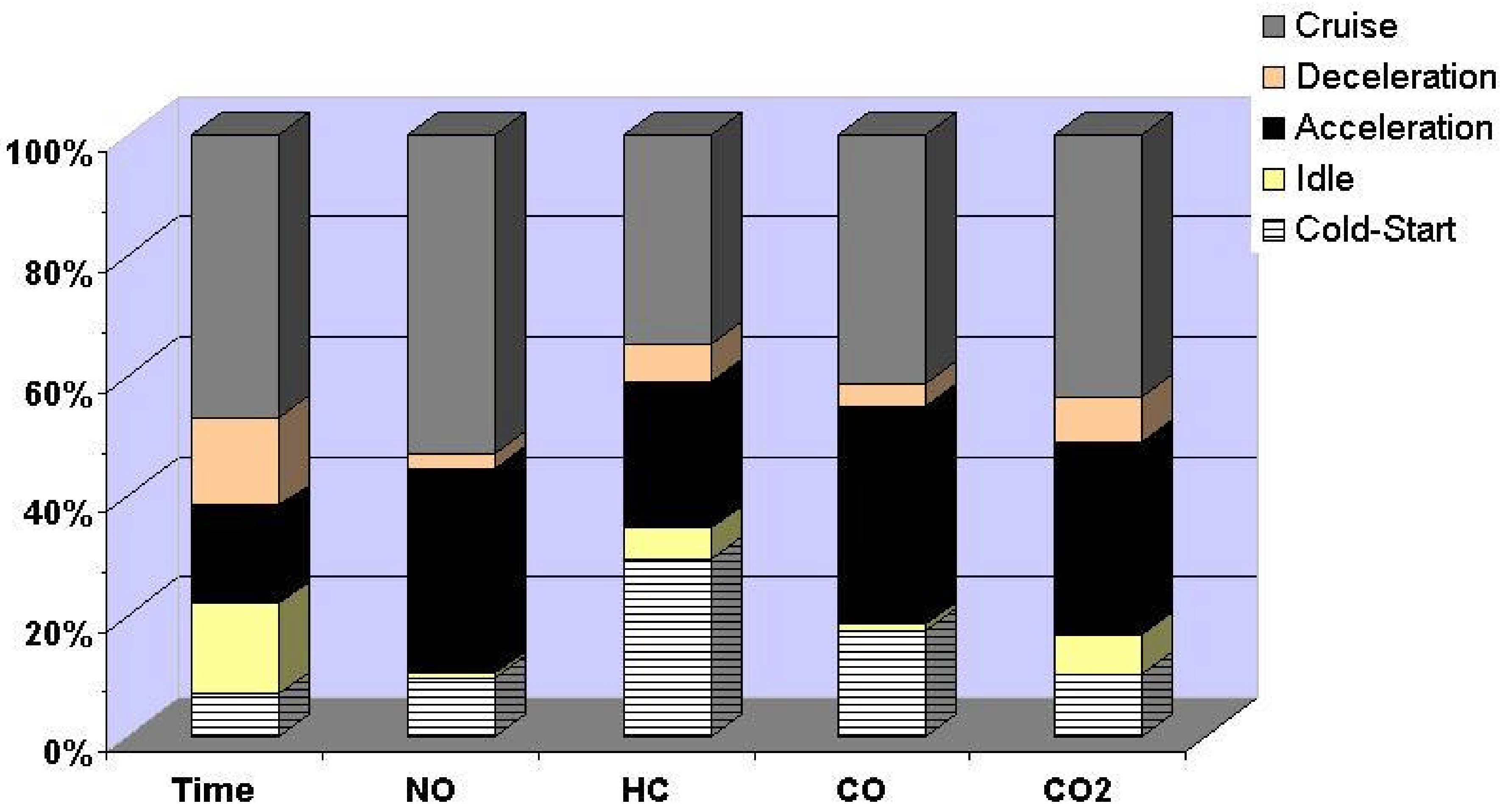
Real World Bus Emissions



Second-by-Second Cold Start Data



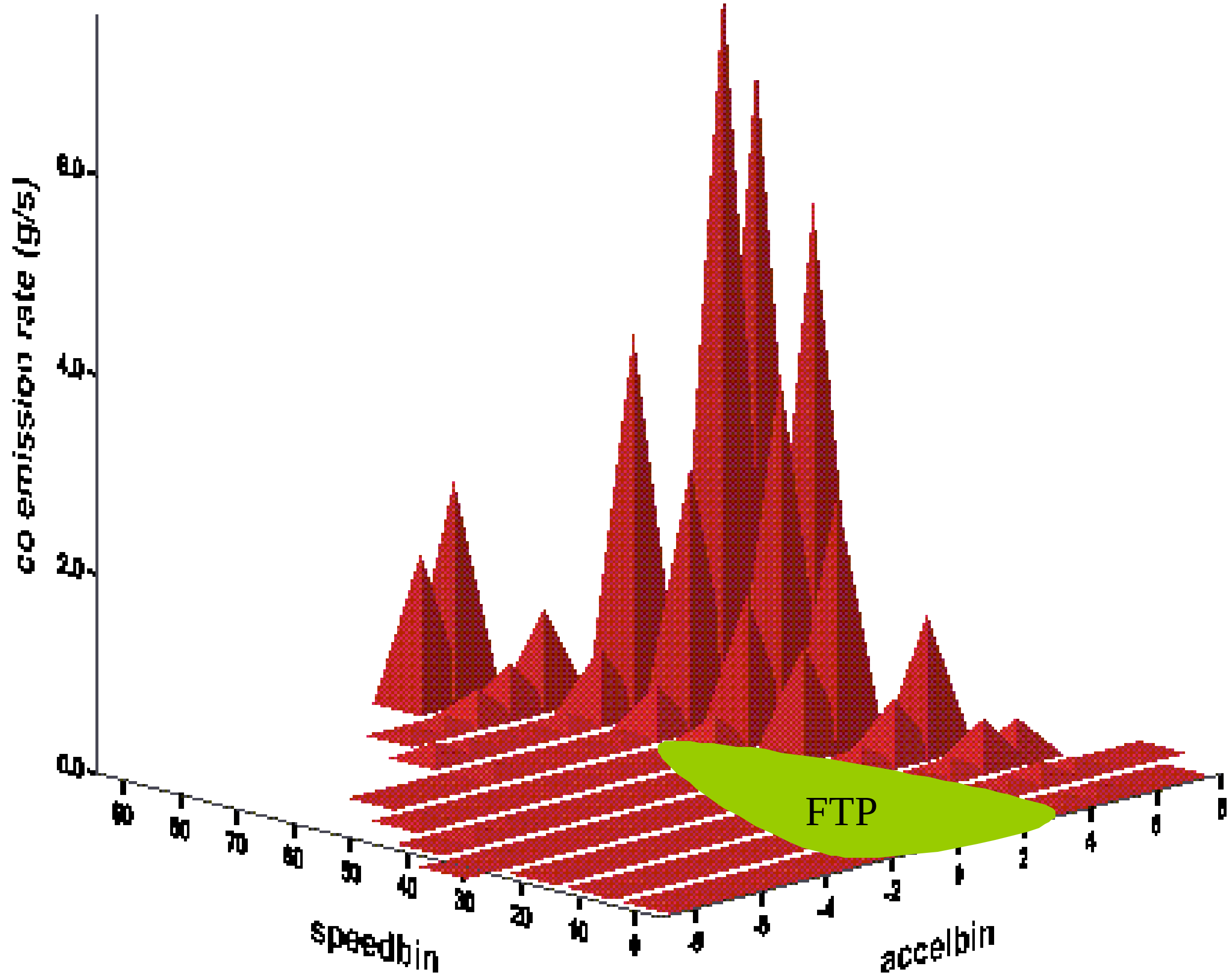
Accel More Important



Better Data Collection Methods

- Data collection is expensive
  - Recruiting costs from $2,000 to $100,000 per engine
  - Data collection budgets have diminished dramatically
- New approach and changes in data collection needed
  - Laboratory based recruitment and testing is a compromise both in terms of sampling and geography
  - Laboratory testing regimes don't reflect real world, in-use operation of vehicles and engines

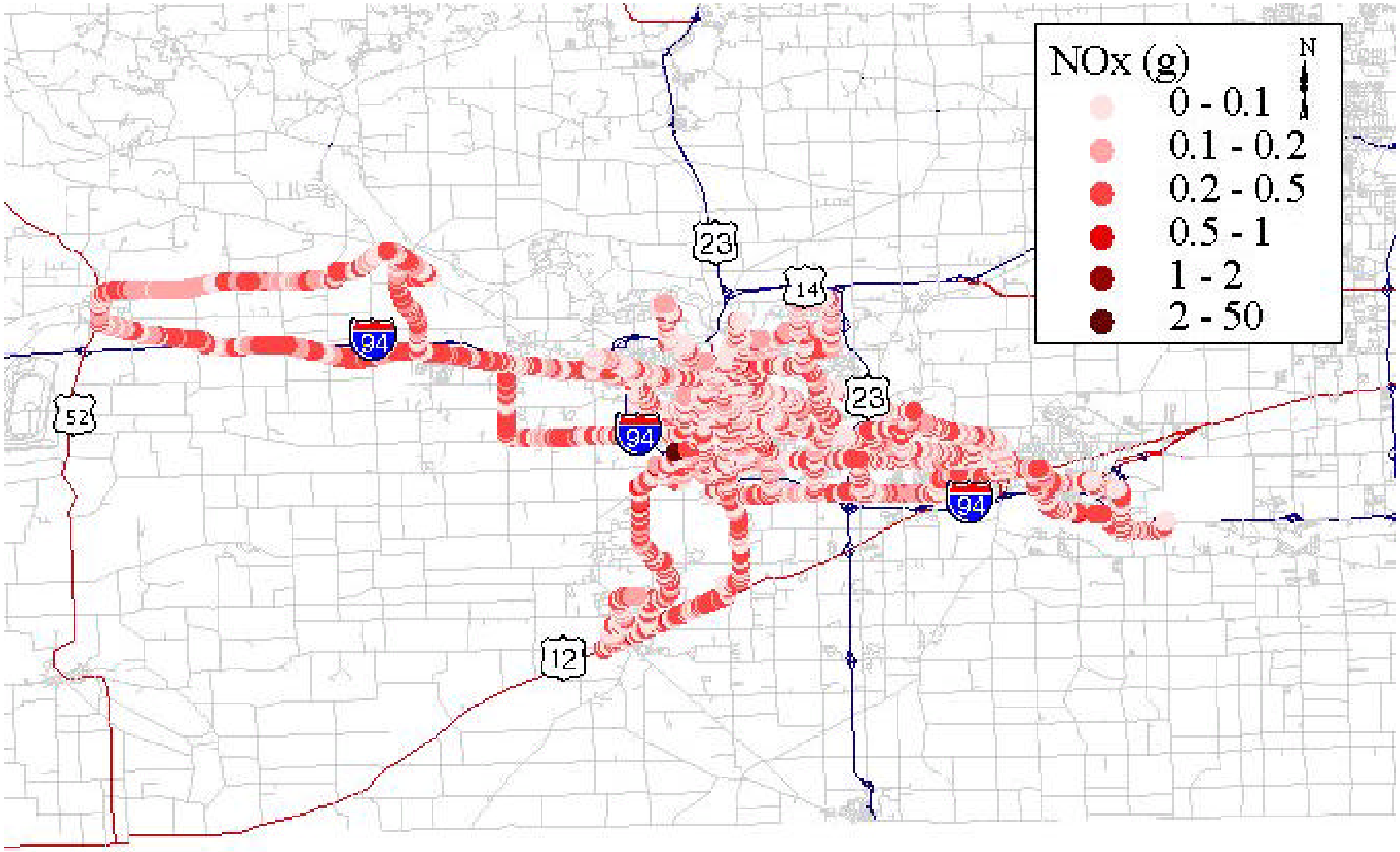
Real World vs. Lab



Measuring Emissions in the Field

- Portable emission measurement systems
  - Allows us to bring the lab to the car or engine and test it on the road or in the field under normal operating conditions
    - These conditions are not adequately represented by laboratory driving cycles and “correction” factors used in models
    - Shows both how and where emissions are generated
  - Frees us from the few laboratories around the country
    - We can test anywhere, any time
  - Reduces problems related to sampling and modeling
    - Can test anything we can recruit
    - Less intrusive technology increases chances of high recruitment participation

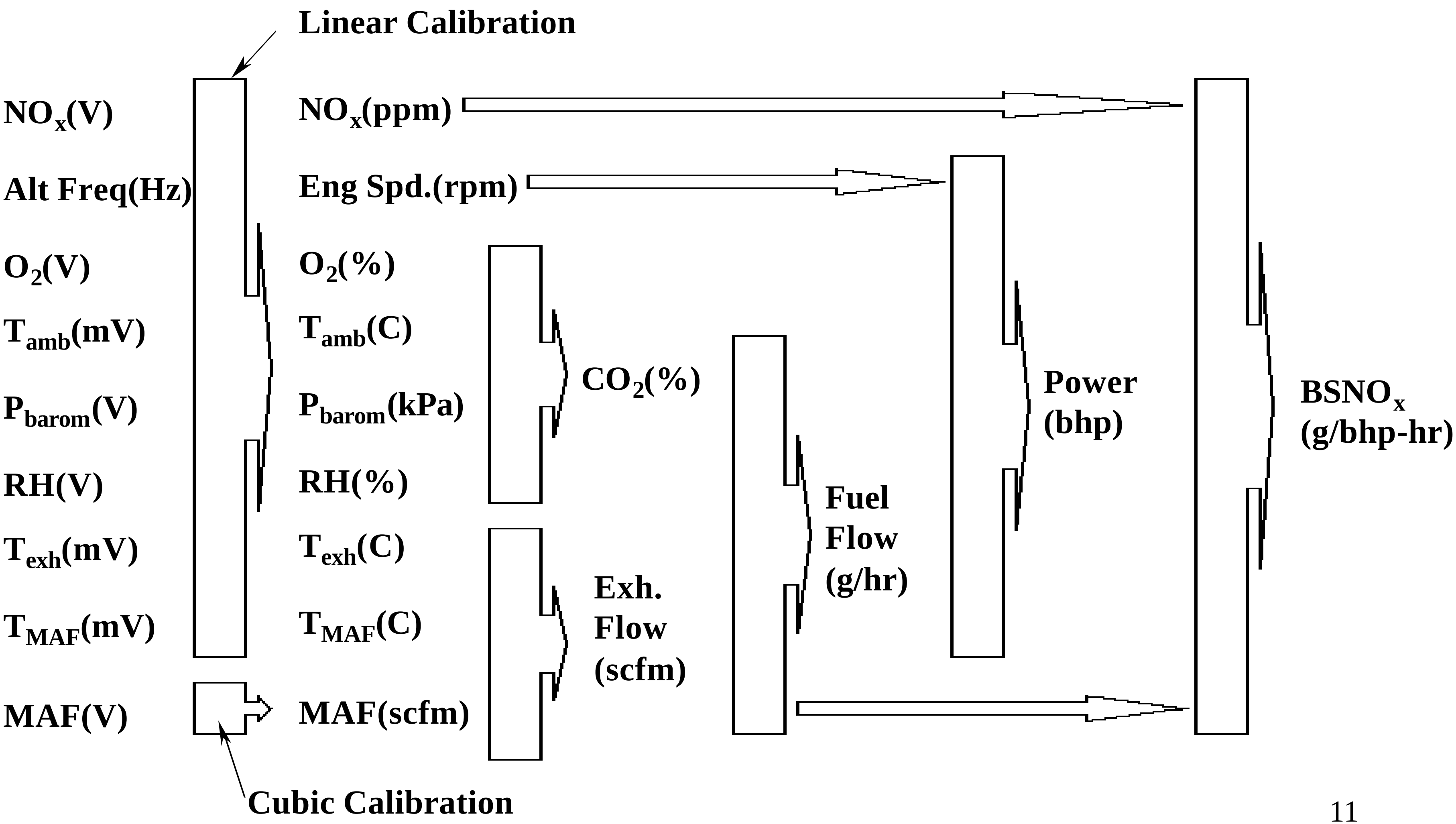
Emissions Where They Occur



Technology Development

- Goals
  - Bring technology to market
  - Make accurate, accepted equipment readily available
  - Specify EPA needs so manufacturers can respond
- Approach
  - Cooperative Research and Development Agreements
    - Measure gasoline and diesel emissions
    - Operate unattended for extended periods of time
    - Accuracy requirements approach lab measurement
    - Goal is to have commercially available products in ~6 months
  - OTAQ lab and contractor development
    - PM and toxics measurement capability
    - Measurement strategy development

Emissions Calculations

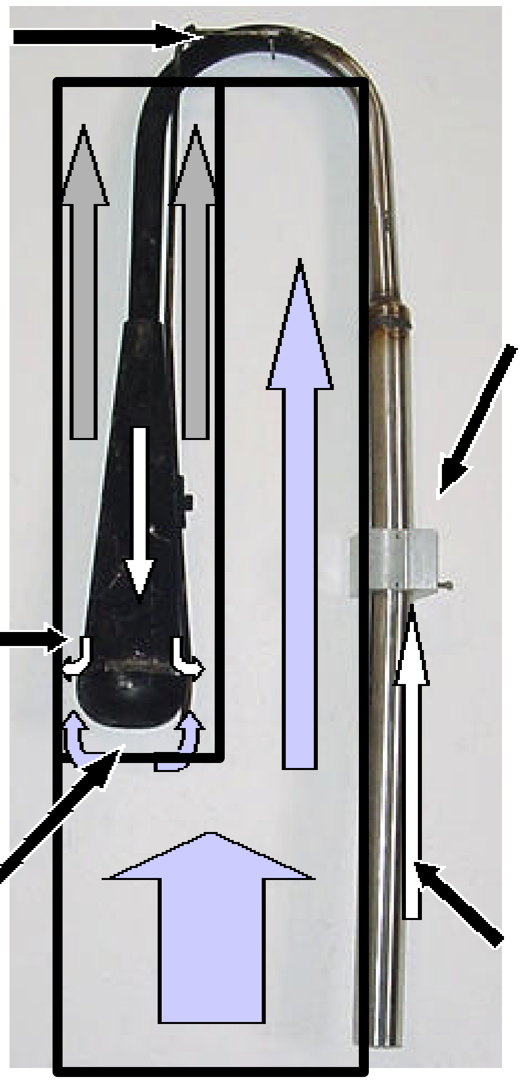


SPOT
Simple Portable Onboard Test

- Magnetic mounts
- Heavy-duty locks
- Cellular, GPS, & CAN capability
- Zirconia sensor: total-NOx & O2
- Unique exhaust flow measurement
- Fuel-specific & mass rate emissions
- Brake-specific emissions based on power estimate

EPA-supported innovation

NO_x/O_2 sensor



Annular eductor

Partial exhaust flow

MAF sensor

Air flow in

Non-road Exhaust Flow Measurement

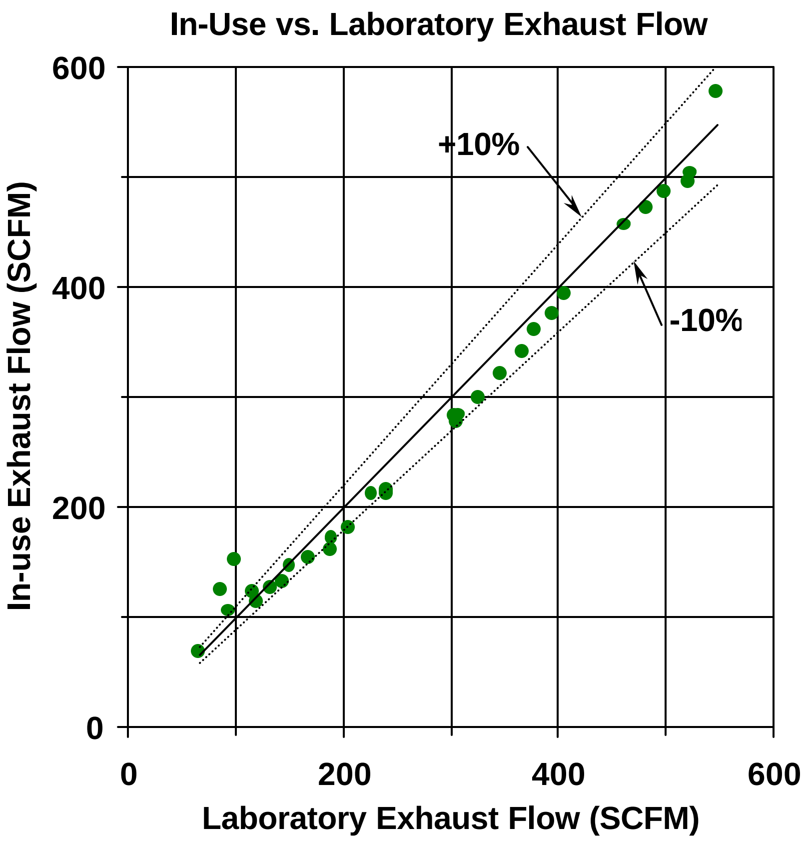
- Low pressure drop
- Fast response
- Durable sensors
- Linear calibration
- Self-cleaning

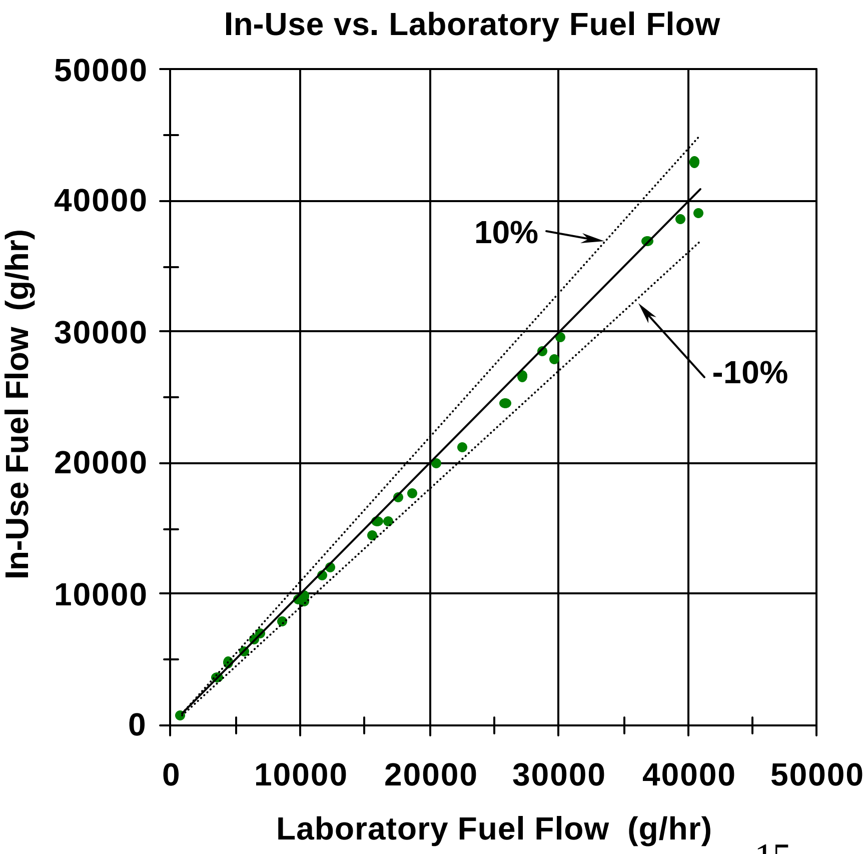
Non-road Exhaust Flow Device

Fuel and Exhaust Flows

$$ExhFlow(scfm)=(C_1(D_{exh}/D_{meter})^2+C_2)*MAF*(T_{mafabs}/T_{exhabs})^{0.5}$$

$$FuelFlow(g/hr)=ExhFlow*CO_2/100*(12.01+H{:}C_{ratiofuel}*1.008)(g/mol)*60(min/hr)*1.178(mol/scf)$$

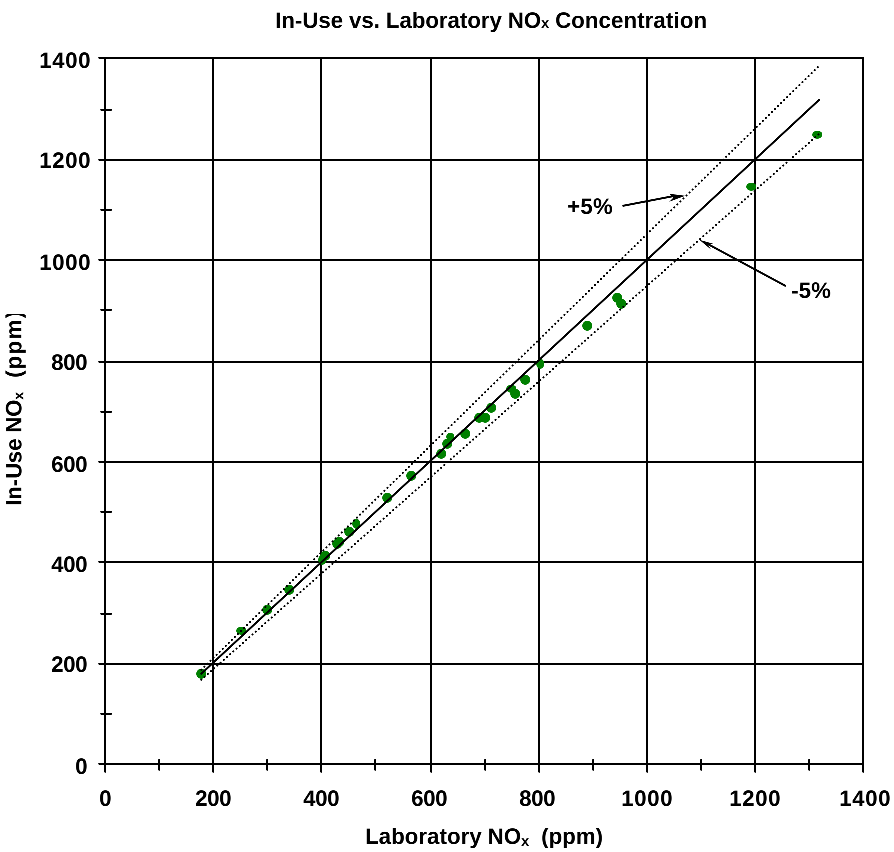


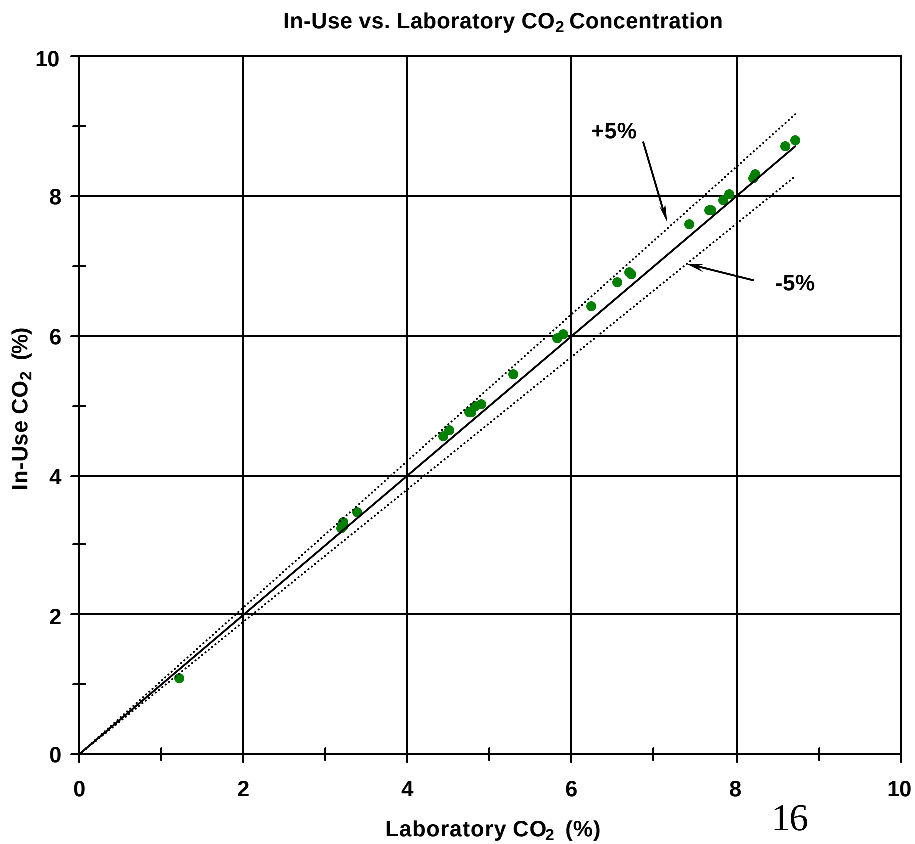


Emissions Concentrations

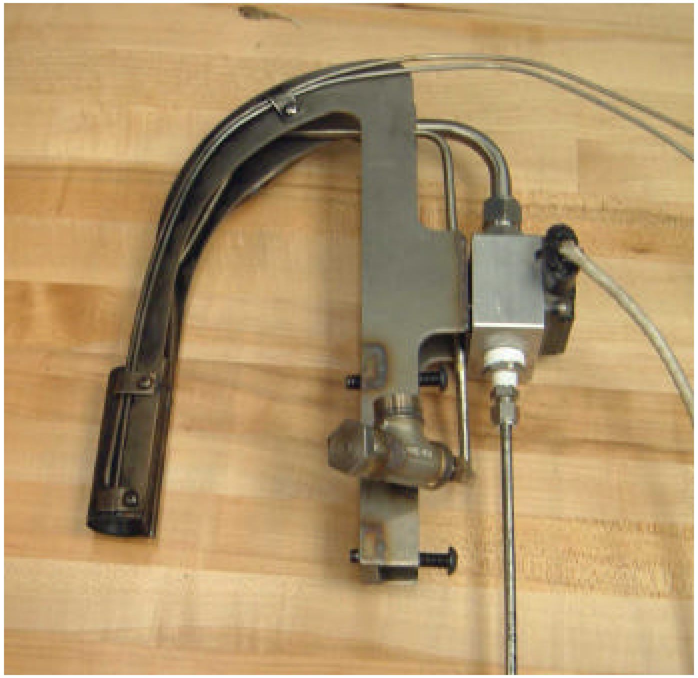
$$CO_2(\%)=(20.99*(1-(RH/100)*(P_{sat}/P_{barom}))-\%O_2-0.55*(NO_x/10000)/(1+0.3025*(H:C_{ratiofuel}))$$

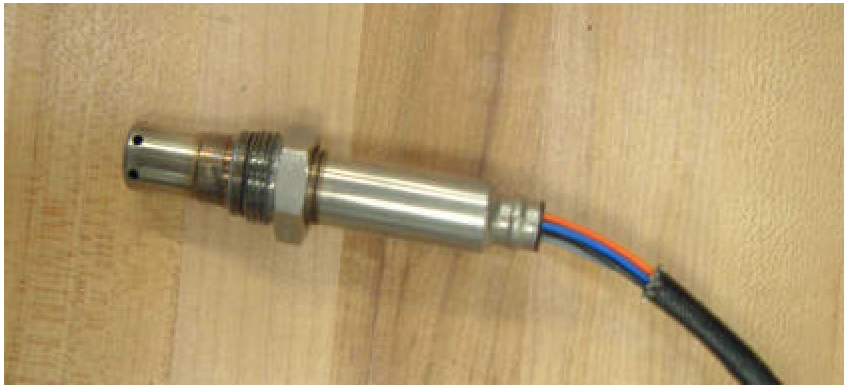
$$P_{sat}(kPa)=1.775E\text{-}9*T_{amb}^{5}+3.687E\text{-}7*T_{amb}^{4}+2.483E\text{-}5*T_{amb}^{3}+1.395*E\text{-}3T_{amb}^{2}+4.578*E\text{-}2T_{amb}+.6031$$

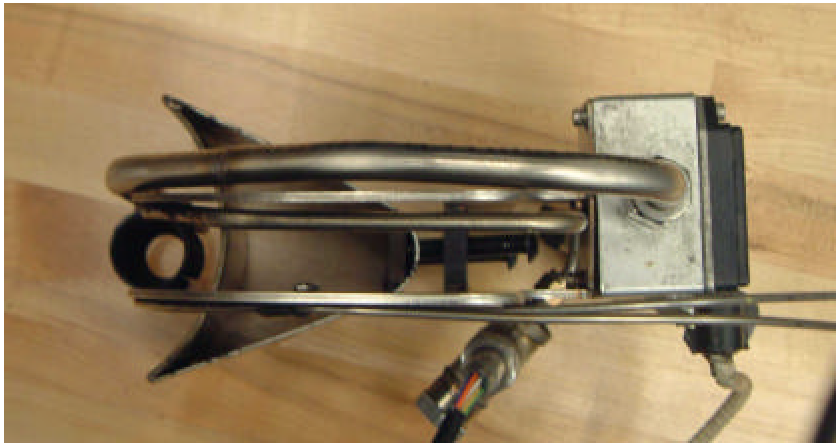




Flow Device Version 3







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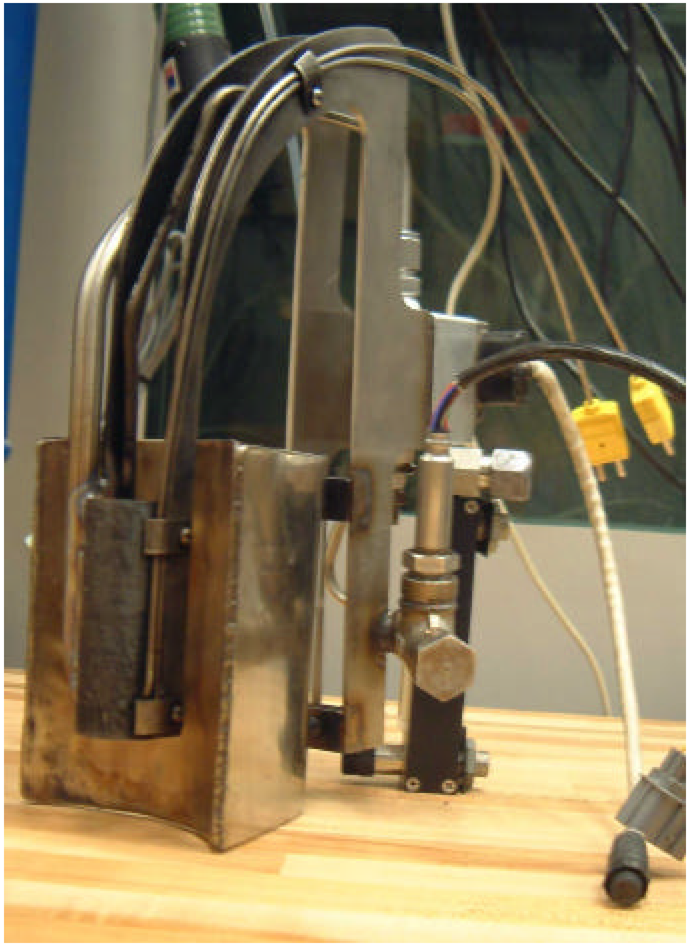
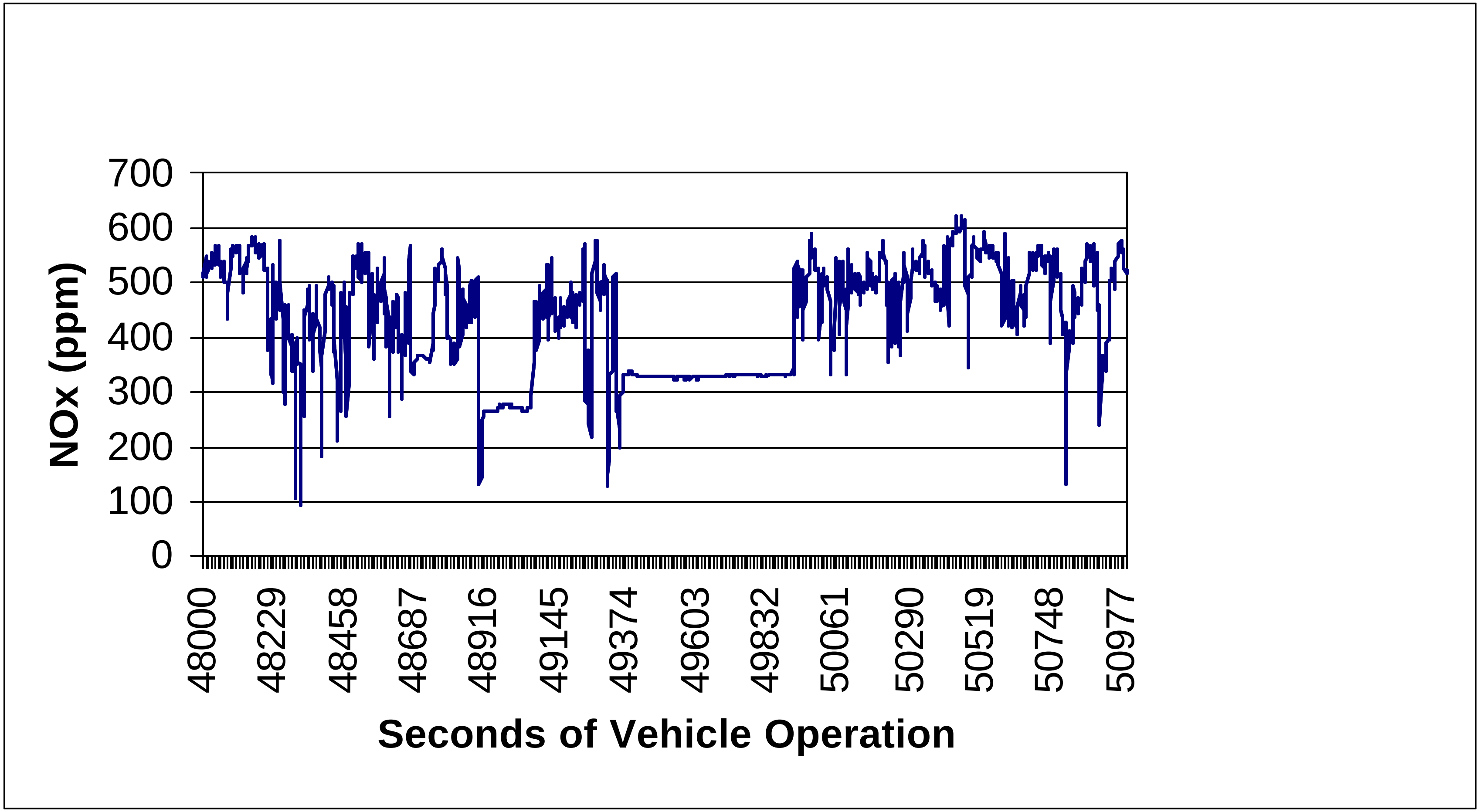


Nonroad Emissions Data



PM Development

- Developing related measurement capability
  - Proportional sampling system
  - Humidity conditioning of exhaust sample
  - Preclassifier
- Evaluating continuous PM monitoring
  - Quartz crystal microbalance
  - Tapered element oscillating microbalance
- Time line
  - Expect prototype evaluations completed by Summer